by Gerry O'Hara, G8GUH

'Technical Shorts' is a series of (fairly) short articles prepared for the Eddystone User Group (EUG) website, each focussing on a technical issue of relevance in repairing, restoring or using Eddystone valve radios. However, much of the content is also applicable to non-Eddystone valve receivers. The articles are the author's personal opinion, based on his experience and are meant to be of interest or help to the novice or hobbyist – they are not meant to be a definitive or exhaustive treatise on the topic under discussion…. References are provided for those wishing to explore the subjects discussed in more depth. The author encourages feedback and discussion on any topic covered through the EUG forum.

Eddystone Circuit Elements

Introduction

There are usually many ways of doing the same job in electronic circuits, improving on how things have been done before, or doing new things altogether: innovation in any of these forms is a good thing. Many receiver manufacturers have thrived on bringing out novel circuitry for almost every model they brought to the marketplace: such innovation was driven by a variety of reasons (just as it is today), including:

- Provide a competitive technical 'edge' over the competition in terms of performance, eg. higher sensitivity, selectivity, frequency range covered;
- Provide new features, a combination thereof, or increased automation;
- Miniaturisation and/or portability;
- Improve ease of operation, perhaps with some ergonomic input to the control layout, so less skill is needed to attain the same performance;
- Reduce costs to provide the same results – potentially increasing profits; and
- Utilize a new technology(s), either because the market demands it, it is 'fashionable', or it does actually improve performance.

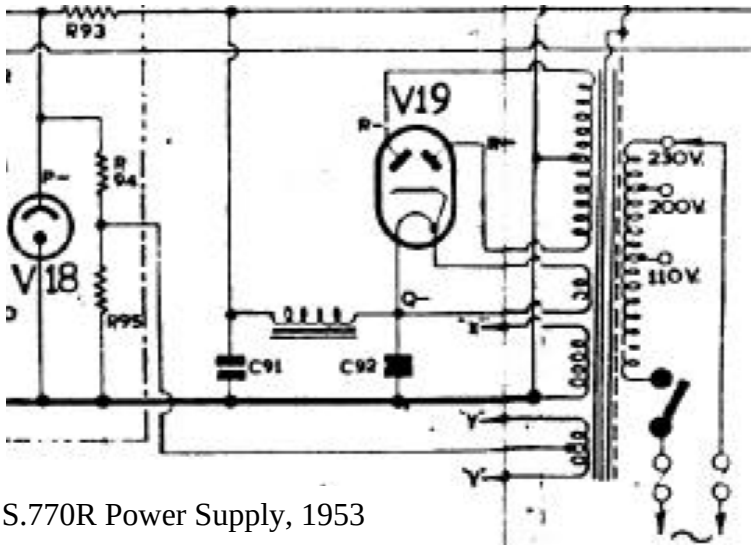
The Eddystone Way…

Although I have only been working on Eddystone receivers for the last year or so, following a break of almost three decades, I have realized that the folks at the 'Bath Tub' back in the 1940's through 1970's had a seemingly pervasive philosophy - whilst innovation was prevalent, the real Holy Grail appeared to be quality, solid construction, reliable performance (close to the state-of-the-art, but not at the expense of unreliability or gimmicky circuitry) and, very importantly, ease and simplicity of operation. This approach, rather than sets that had 'feature overload' or who's internal construction and circuitry was overly-complex and which may only provide a marginal increase in performance at the expense of decreased reliability, operator confusion, increased service

cost/downtime and price, was somewhat unique and very, er, 'British' – check out sets from some other leading communications receiver manufacturers of the same period, especially from the US. Of course, Eddystone were in a competitive world, selling their wares in a variety of markets: military, professional, maritime, radio amateur and domestic. For each market sector, Eddystone applied the same philosophy, though successfully adapting it to suit the 'job in hand' and customer base. This manifested itself in the use of many 'standard' receiver circuit configurations that were used in a variety of sets throughout this period (over 25 years), with only slight modifications (if any) once they proved their performance and reliability in use. Such standard circuit elements, eg. BFO circuit, crystal filter, cascode RF amplifier or push-pull output stage, were 'mixed and matched' between models to great effect. Also, many major components were common to different models, sometimes decades apart on the production line – I am sure that this allowed the Eddystone R&D budgets to be expended on other, better, things than mindlessly re-inventing the wheel for the sake of it as many other companies were apt to do. I am not saying that the Eddystone designers were staid, just prudent, ahead of the game and more in the 'if it ain't broke, don't fix it' school than those in some other manufacturers design shops. However, good receiver design is not just about the circuit elements and how they connect together: a good receiver must be built right (electrically and mechanically), feel right (ergonomics – control layout, type and range), be stable, reliable, be service-friendly and allow the operator to control it almost by second nature. Eddystone were successful in achieving all that. Indeed, not only did some of the same circuit elements keep appearing in different models through over two decades because they were good, but whole sets were re-packaged with only minor electrical changes for long periods, and remained 'good sellers' throughout, testament indeed to both the Eddystone philosophy and the reliability, quality and advanced nature of the original design. This Technical Short sets out to identify some of the more standard circuit elements used by Eddystone during this period and illustrates similarities noted by the author using 'clips' from the set's circuit diagrams.

Some 'Standard' Eddystone Circuit Elements

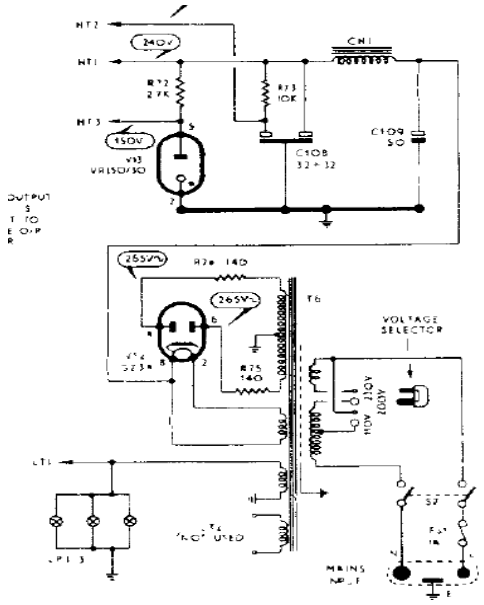
AC Power Supplies



S.770R Power Supply, 1953

The Eddystone designers did not expend excessive effort on the design of their AC power supplies, usually limiting the job to an over-specified mains transformer, eg, type 3937P, which often had a heater winding unused, fuse-protection, a full-wave rectifier, capacitor/choke smoothing, additional capacitor smoothing on the first audio HT line and, in

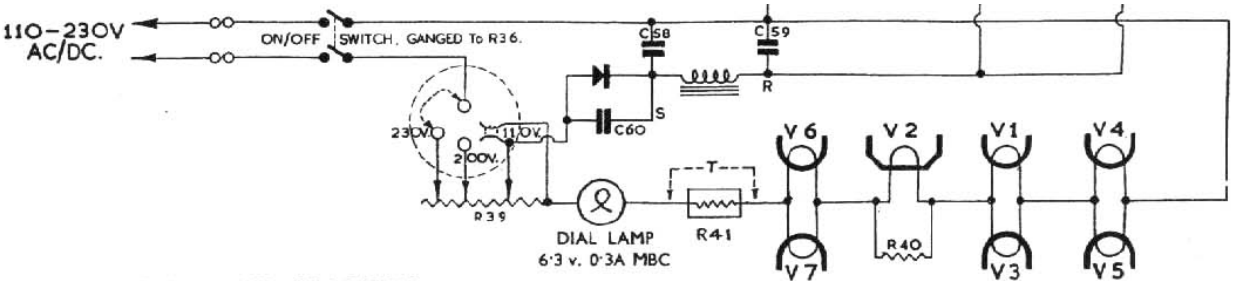
S.940 Power Supply, 1962 to 1970



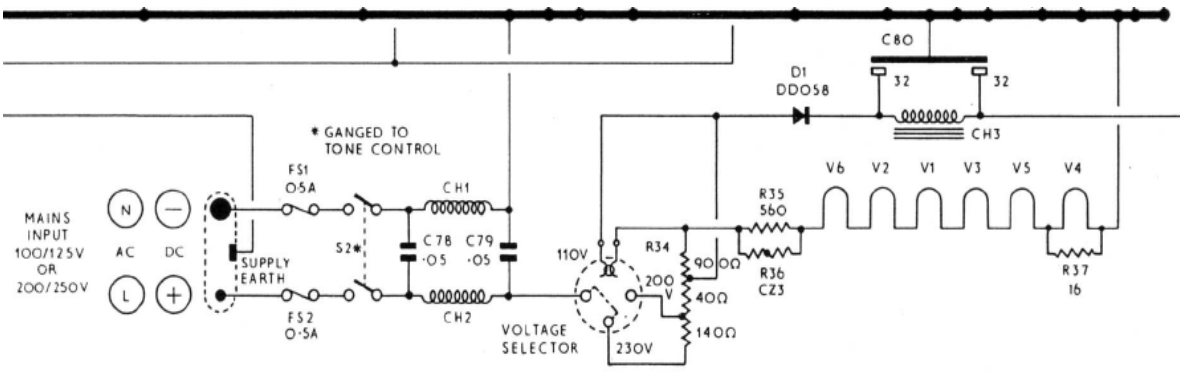
many sets, one, or even two, cold-cathode valve stabilized HT supplies feeding the local oscillator(s) and BFO. AC power supplies from sets from the immediate post-war period, eg. S.556 and S.640, through the 1950's model S.750, S.770R and late-1960's (eg. S.940) were all similar, with the main differences being in the location of the fuses, presence of a stabilizer(s), and the presence (or not) of surge-limiting resistors between the transformer HT windings and the rectifier anodes. Some sets, eg. 830 series, replaced the valve rectifier with silicon diodes.

AC/DC Power Supplies

'Universal' or 'AC/DC' power supplies are normally associated with low-end domestic radios (especially in the US, where the 'all-American 5' design was the epitome of this configuration, where eliminating the mains transformer reduced the cost, weight and complexity of the receiver 'at a stroke' – these sets had 'adequate' performance on the am broadcast band for casual listening and often used less than 40 components!). So why did a manufacturer with the 'Eddystone philosophy' manufacture AC/DC sets? – primarily to meet the needs of the marine radio market – where DC supplies ruled: apart from the change in power supply type though, the Eddystone AC/DC sets were of similar quality to the Eddystone domestic models. A separate 'Short' covers AC/DC sets in more detail, however, here it

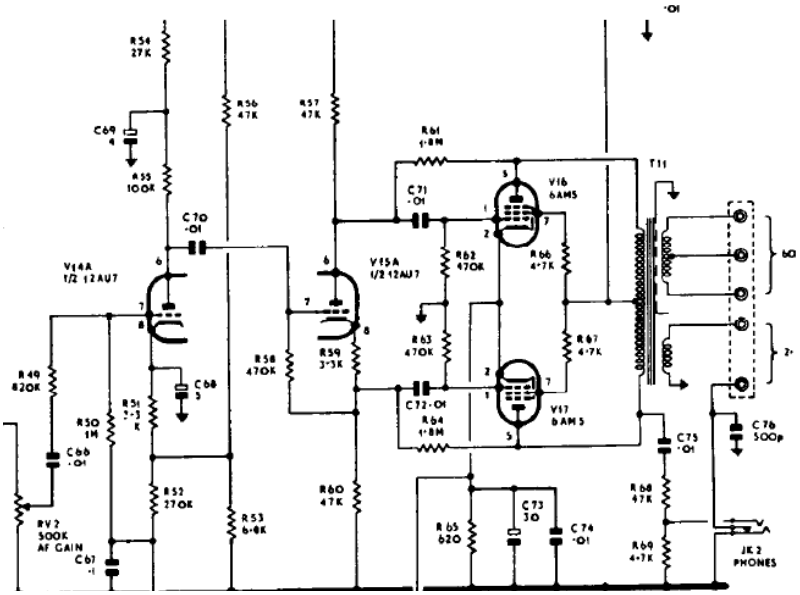


Above, S.670 Power Supply, 1948; below, S.670C Power Supply, 1963-67

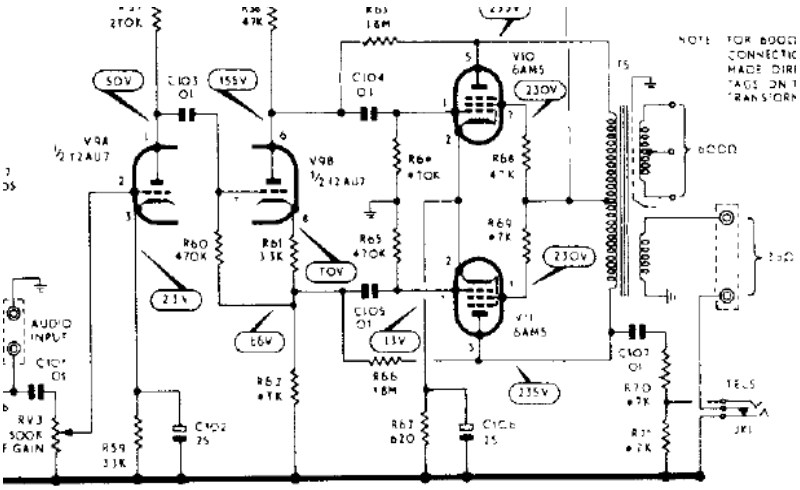


is suffice to say that the AC/DC power supply 'circuit element', with little variation, was a standard fixture from the introduction of the first such set, the S.670, in 1948, through the 870A in the mid-1960's and also the 840C, the latter manufactured until 1968. The circuit essentially comprises a voltage selector switch, high-wattage dropper resistor, surge-limiting resistor/thermistor to protect the valve heaters from surges at switch-on, a half-wave solid-state HT rectifier and a capacitor/choke filter. The valve line-up in these sets used a variety of valves with heaters in series (or series-parallel) configurations. These, when combined with a series resistor(s) as appropriate, dropped some ~120volts total, the remaining voltage, when the set was used on a 200v or 240v supply, being dropped across the high-wattage resistor: all standard and reliable stuff, the only reported 'problem' being the large amount of heat expended by the high-wattage dropper resistor.

Push-Pull Output Stage



1960's audio stages: above, S.770-U MkII; below, S.940: the final (push-pull) section is identical apart from an extra by-pass capacitor in the S.770-U MkII



Many Eddystone sets were fitted with a push-pull output stage of very similar design.

I suspect that use of the push-pull circuit may have been a marketing 'thing' in some cases, with slightly more output power coming at the small cost premium of an extra valve and a few passive components: the output power was comparable to many of the single-ended stages used in other models, eg, a single 6AQ5 can provide over 2.5 watts, and two 6AM5's (or similar) in push-pull provide only 3.5 watts – not that much difference to the ear (and some would argue that a single class-A audio amplifier also gives a better-sounding audio). Almost identical push-pull circuitry was deployed in the S.770R in the early

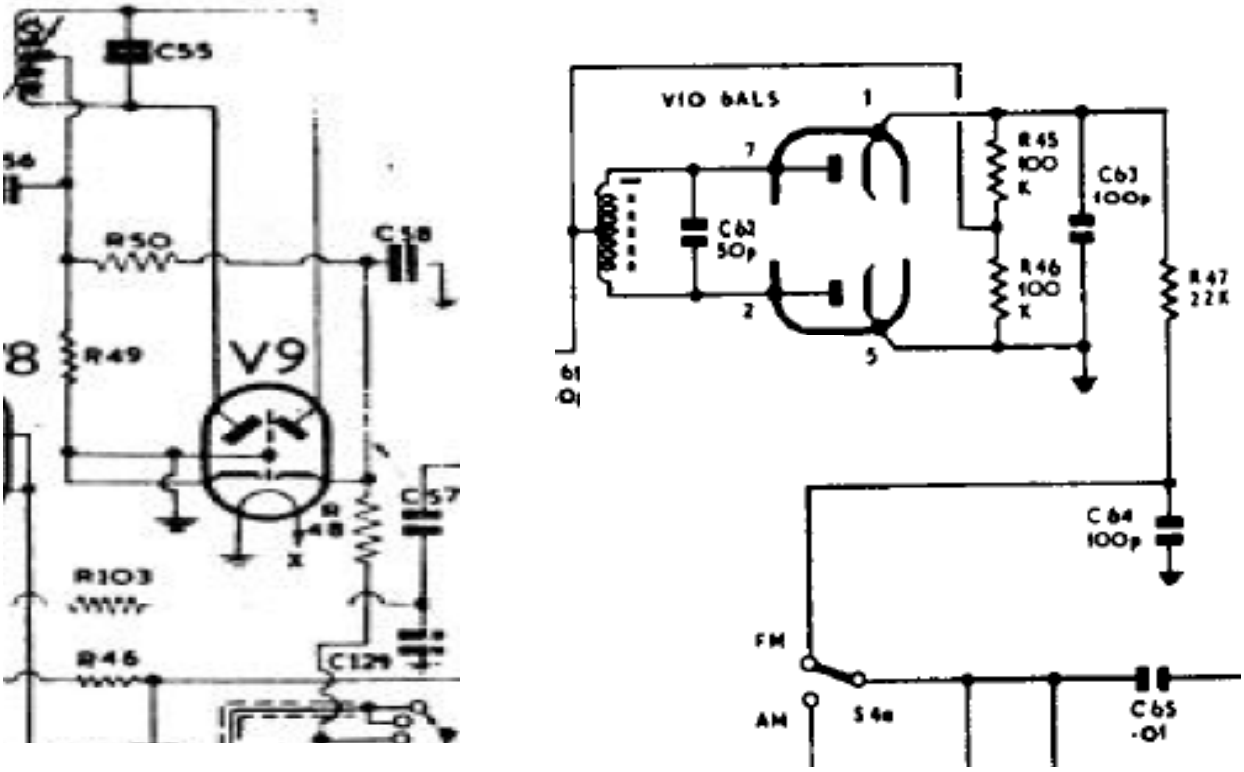
1950's and the S.940 from 1962 through to 1970: simple, reliable and effective.

Detectors and Noise Limiters

Eddystone used several different AM detector circuit arrangements over the years, often depending on the selected audio stage configuration: sets using a single (pentode) output stage tended to use one of the diodes in a duo-diode-triode valve, eg. 6AT6, with the triode section as the first audio stage, whereas those sets with push-pull output, which had a duo-triode for first audio and phase splitter (eg. 12AU7), used one half of a duo-diode for an AM detector, eg. 6AL5 - not always the case, however, as in the 730/4.

With the increasing popularity of SSB in the late 1950's, Eddystone introduced product detectors in some models, eg. in the S.888A, S830 and S.940. Similar circuits were generally used, deploying a 6BE6 valve integrated with the BFO.

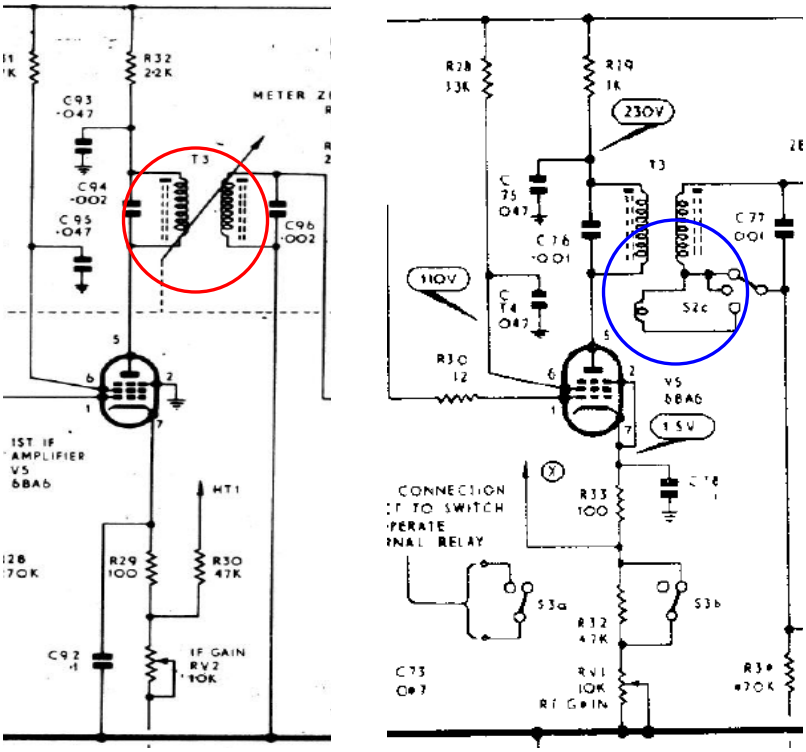
Sets that included FM facilities, eg. S.770R/U models, included a Foster-Seeley discriminator of a fairly standard design.



S.770R MkI discriminator, left (1953) and S.770-U MkII, right (1964 – 1969)

IF Stages

Similar IF stage amplifiers were used in sets of this period, usually using the reliable variable-mu 6BA6 pentode with standard biasing arrangements, with AGC applied, and often with a manual gain control, either as a separate IF gain control as in the S.750 and S.830 series, or combined with the RF gain control, as in the S.940. The real Eddystone 'strength' and innovation here was in the quality of the IF transformer construction and the facility to vary the selectivity, either by mechanical or electrical means (see my Tech Short on receiver selectivity and crystal filters for more details on this).



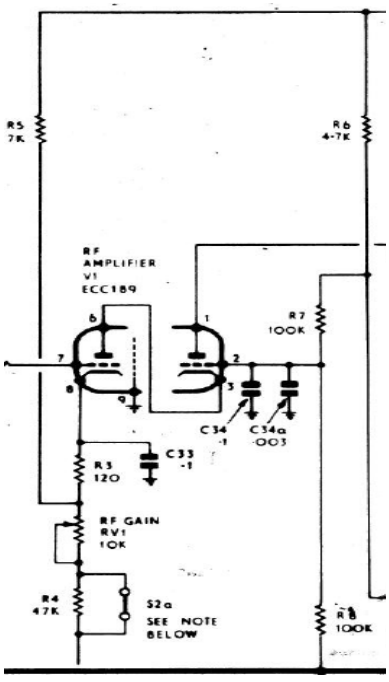
S.830 series 2nd IF stage (left), showing mechanical adjustment of IF selectivity (circled red), and the S.940 2nd IF stage (right) showing a similar circuit but here using switched tertiary winding on the IF transformer to vary selectivity (circled blue)

AGC

A separate diode is used to generate the AGC voltage in Eddystone sets of this period. This is coupled in the normal way to the IF and RF stage valve grids through high-value resistors, as well as the mixer stage in some cases (mixer theory would indicate that the latter to be ill-advised, however, I am sure the folks at the Bath Tub had their reasons…), however, some 'modders' recommend removing the AGC from the mixer stage to improve performance.

RF and IF Gain Controls and 'Send' Switch

These gain controls use a 10kohm linear (or, in some cases, a specially-wound semi-log) wire-wound pot, wired to change the grid bias of the RF stage(s) and IF stages. Later designs (and a modification brought in during the production life of some sets, eg. S750), applied HT to the control circuit to



S.830 series (cascode) RF stage showing typical RF gain control and standby/'send' switch arrangement

provide a wider control range - see the RF and IF circuit examples above.

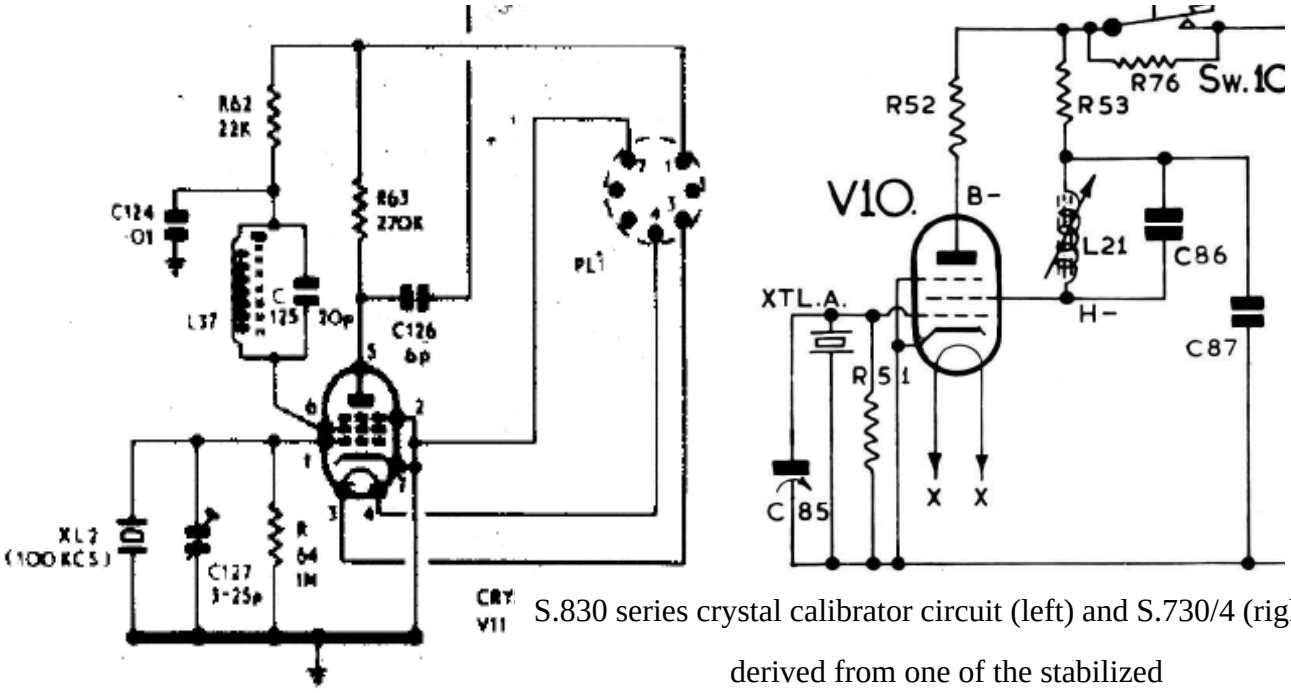
The 'send' or 'standby' switch introduced an even higher level of grid bias in the same circuit (the switch normally closed, shorting out a resistor), effectively de-sensitizing the receiver while a transmitter was in use.

Crystal Filters

Many Eddystone sets intended for the military, radio amateur and professional markets included a single quartz crystal filter between the mixer and first IF stage. The Tech Short on receiver selectivity and crystal filters provides detailed description of these circuits – suffice to say here that, apart from some changes to the matching arrangement to the input of the first IF stage, the circuits were almost identical from the S.640 in 1947 to that in the S.940, last produced in 1970. Several example circuits from Eddystone receivers through the years and further discussion can be found in the Tech Short on receiver selectivity and crystal filters

Crystal Calibrators

These were added as a 'bolt on' unit built into a nice little die-cast box, often mounted on top of the tuning gang capacitor cover, its output wafted into the tuning gang/coilbox areas either by a small-value capacitor or by just stray coupling. Its HT supply was

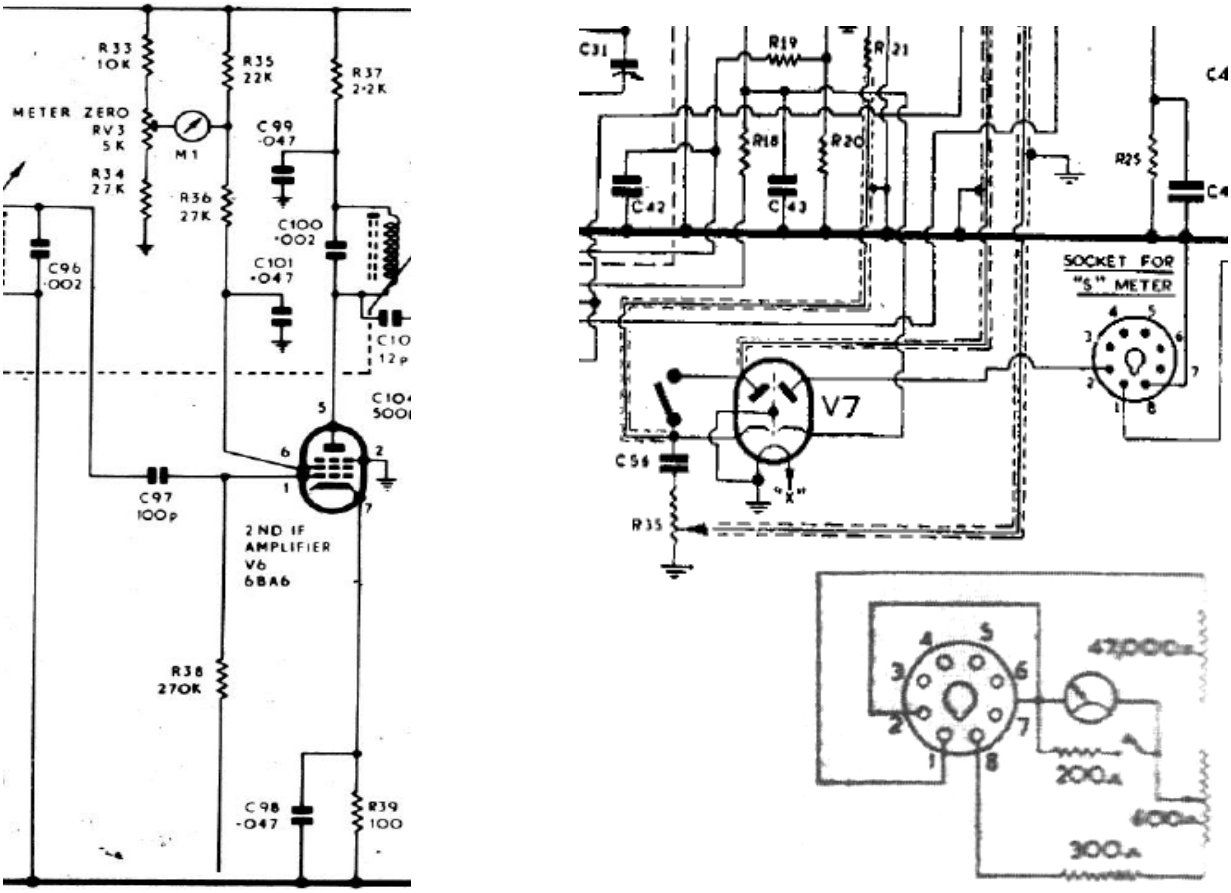


S.830 series crystal calibrator circuit (left) and S.730/4 (right)

derived from one of the stabilized supplies via a momentary-action toggle or pushbutton switch. Identical crystal calibrator circuits were fitted to the 730/4 in the mid-1950's as to the S.830 series in the early 1970's. The pushbutton switches are noted to give trouble (see S.830 'Achilles Heel' article in Lighthouse).

S-Meters

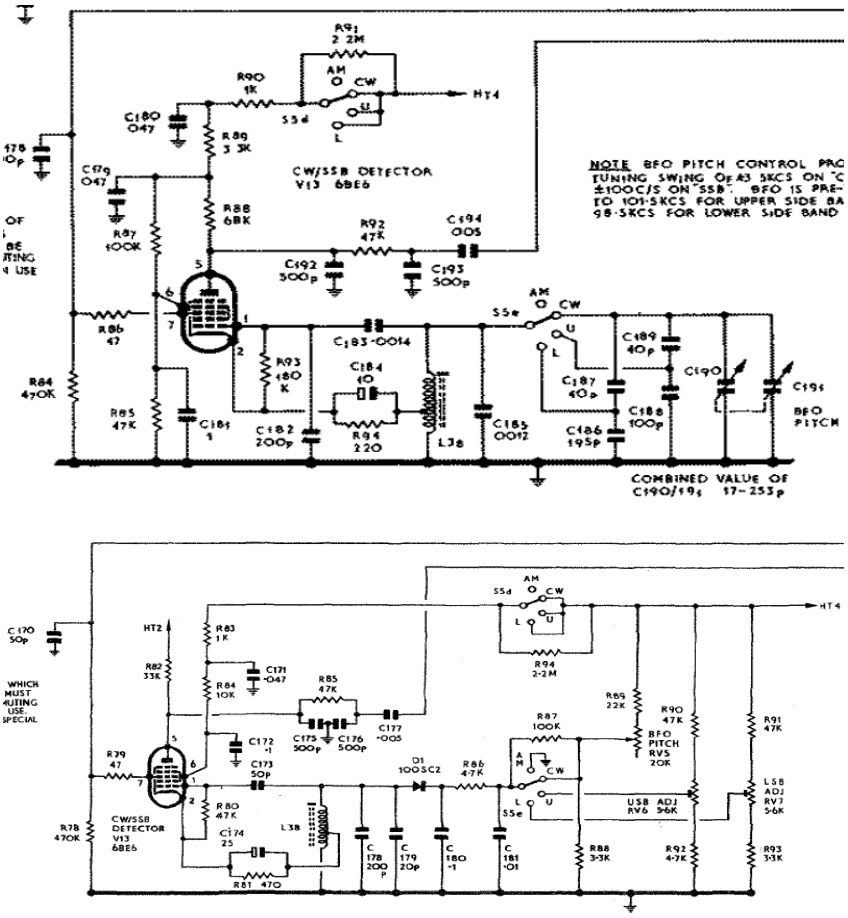
Two basic S-meter circuits were used in the Eddystone valve receiver 'Golden Years': one forming part of a resistance bridge circuit in the final IF stage screen grid, used on sets fitted with internal S-meters, such as the S.830 series, S.770R and S.940; and one forming part of a resistance bridge circuit connected to the cathode of the final IF stage, used in sets having facility for an external S-meter, eg, the S.640, S.740, S.750 and S.888 models.



S.770U/R, S.940 and S.830 series S-Meter circuit (left) and S.640, S740, S.750 and S.888 circuit (right), the latter being an external unit connected by an Octal connector

BFO (and Product Detector)

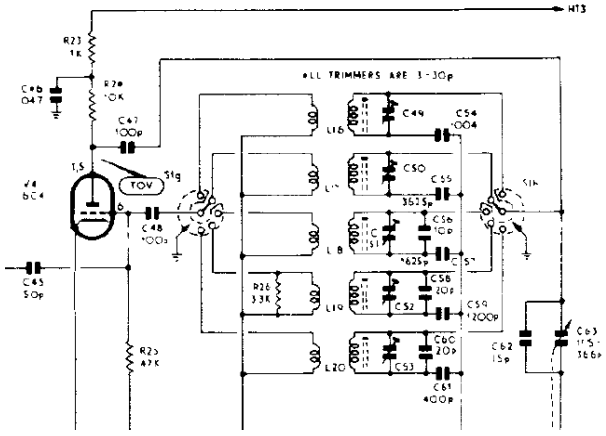
Eddystone used a simple Hartley oscillator for their BFO circuit when a product detector was not present. When a product detector was used, a similar circuit configuration was



common to numerous models, eg. the S830 series and S.940). Some minor variations were tried, perhaps one of the most innovative being the use of a varicap diode in some of the S.830 series, with the tuning being via a potentiometer, with two pre-sets for upper and lower sidebands (strangely, the earlier models, through to the 830/4 had this arrangement, with the S.830/5 onwards reverting to variable capacitor BFO tuning, see circuits, left) – I am sure there were good reasons for this…

Local Oscillator

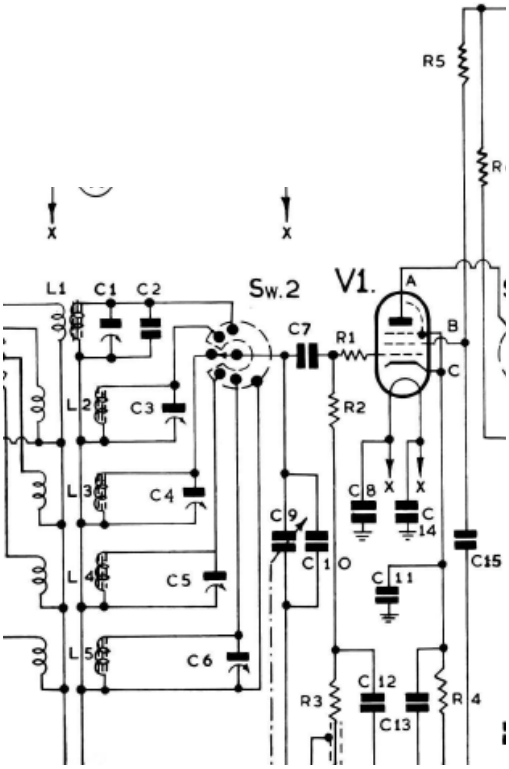
Many Eddystone models used a separate local oscillator valve, usually a triode (eg, 6C4), though in other models a pentode was used, as in the 830/7 (half of a 6U8). Temperature compensation was usually simple: a negative temperature coefficient capacitor in parallel with the oscillator tuning capacitor (C62 in the S.940, right).



S.940 local oscillator – nice 'n simple…

Pentode RF Amplifier

Nothing too innovative here: most pentode RF stages in the HF receiver ranges from the late-1940's through early 1970's were almost identical, although the valves used changed from the Octal-based EF39 in the S.504 and S.640 in the mid-1940's, through the B8A-based EAF42 in 1950, eg. in the S.740, to the ubiquitous B7G-

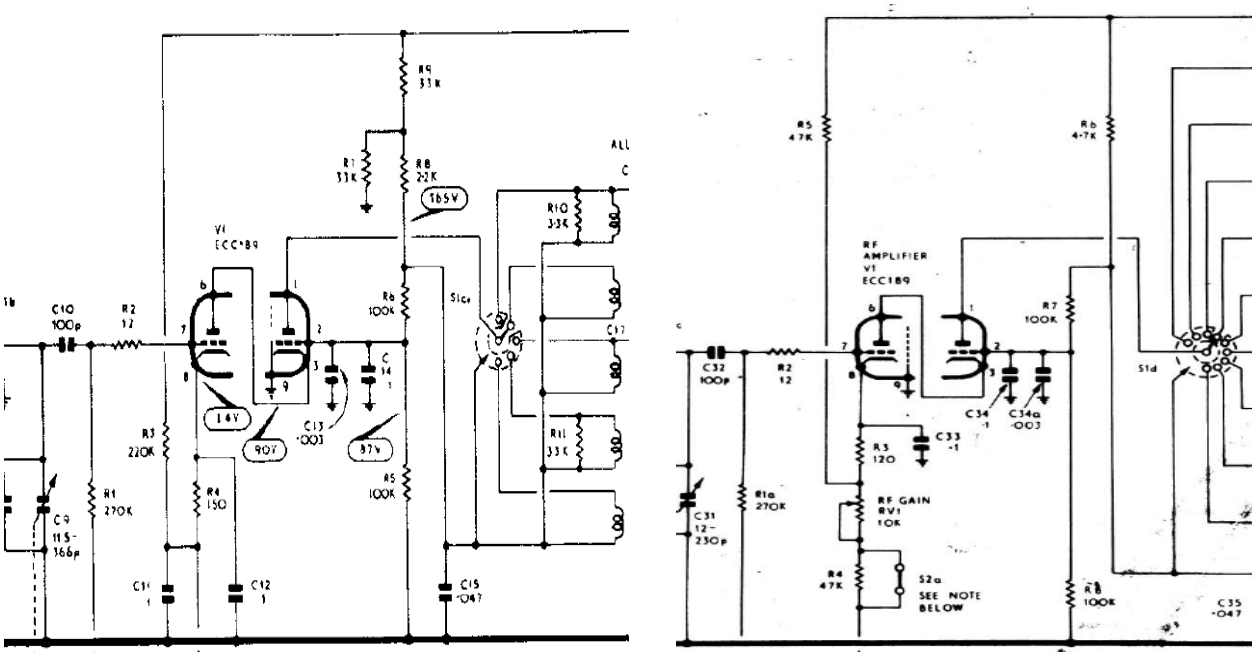


Typical pentode RF stage, here as used in the S.730/4

based 6BA6 in the early-1950's through 1970, eg. as in the S.750, both RF stages of the S730/4, and as the second RF stage in the S.940.

Cascode RF Amplifier

Following its description in the Proc. I.R.E. article in June, 1948 by Wallman, the cascode RF amplifier became popular in the early 1950's, initially to provide a low-noise, stable amplifier for TV sets operating at VHF. A typical cascode circuit uses a dual-triode, the first in common cathode directly coupled (in series) to the second, operating in a common grid configuration. The benefits of the cascode arrangement are also present at HF, eg. noise figures of <0.25db at 6MHz and <1.3db at 30MHz are noted, a higher resistance to cross-modulation and to strong-signal overload. This circuit was introduced into the Eddystone range in the early 1960's - in the S.830 professional series, the EA12 amateur model, and the popular



Cascode RF amplifier stages: S.830 (left) and S.940 (right)

S.940 - to increase front-end specifications of this new range of high-performance HF receivers.

The cascode circuits in these three sets differs only slightly in the biasing arrangements but perform similarly. The S.940 also has an extra stage (pentode) of RF amplification.

Conclusion

Many post-WWII Eddystone receivers use similar circuit elements to perform the same tasks, or sometimes with only minor modifications, between models that may be many years apart in their production period. This practice greatly benefits servicing these receivers as knowledge gained on one model can be applied to others, thus speeding up the repair process. Also, in these days of diminishing availability of Eddystone-specific parts, it allows the exchange of components between different models, eg. I have 'transplanted' a mains transformer from an S.750 manufactured in the early 1950's into an S.940 manufactured in the mid-1960's – this ability is good news for all.

Also, Eddystone tended to use conservative and standard (almost textbook) circuit designs in most of their models. This, when combined with excellent mechanical design, the desire/need to build for arduous use overseas, and for marine and military purposes (as this featured high in their market-share), coupled with the use of high-quality, often over-specified components, made their sets extremely durable. This is evidenced by the large number of Eddystone models still in regular use over five decades since they left the confines of the 'Bath Tub' - I say well done and a big 'Thank You' to all the designers and those involved in the sets production and testing over the years!

Gerry O'Hara, G8GUH, Vancouver, BC, Canada, December, 2006

Some Useful References

- Amateur Radio Techniques, Pat Hawker 6th Ed. 1978 (RSGB)
- Electronics 1-7, Harry Mileaf, 1967
- Various sections of Eddystone manuals downloaded from the EUG web site and specific articles in Lighthouse

Mains transformer from an S.750 (Eddystone Part #3937P, aka Parmeko Type 5084/6D)… or was that from an S.770R,… or even an S.940?